AL-TR-1992-0006

AD-A252 322

ARMSTRONG LABORATORY

A COMPUTER SIMULATION MODELING APPROACH TO ESTIMATING UTILITY IN SEVERAL AIR FORCE SPECIALTIES

Brice M. Stone
Kathryn L. Turner
Jonathan C. Fast

Metrica Incorporated
3833 Texas Avenue, Suite 207
Bryan, TX 77802

Guy L. Curry

Texas A&M University
College Station, TX 77843

Larry T. Looper
Sheree K. Engquist, Captain, USAF

HUMAN RESOURCES DIRECTORATE
MANPOWER AND PERSONNEL RESEARCH DIVISION
Brooks Air Force Base, TX 78235-5000

May 1992

Final Technical Report for Period February 1990 - March 1991

Approved for public release; distribution is unlimited.

AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235-5000

NOTICES

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely Government-related procurement, the United States Government incurs no responsibility or any obligation whatsoever. The fact that the Government may have formulated or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication, or otherwise in any manner construed, as licensing the holder, or any other person or corporation; or as conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

The Office of Public Affairs has reviewed this paper, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

This paper has been reviewed and is approved for publication.

Larry T. Looper

LARRY T. LOOPER
Project Scientist

William E. Alley

WILLIAM E. ALLEY, Technical Director
Manpower and Personnel Research Division

Roger W. Alford

ROGER W. ALFORD, Lt Colonel, USAF
Chief, Manpower and Personnel Research Division

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
May 1992

3. REPORT TYPE AND DATES COVERED
Final February 1990 – March 1991

4. TITLE AND SUBTITLE
A Computer Simulation Modeling Approach to Estimating Utility in Several Air Force Specialties

5. FUNDING NUMBERS
C - F41689-88-D-0251
PE - 62205F
PR - 7719
TA - 20
WU - 20

6. AUTHOR(S)
Brice M. Stone
Kathryn L. Turner
Jonathan C. Fast
Guy L. Curry
Larry T. Looper
Sheree K. Engquist

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Metrica Incorporated
3833 Texas Avenue, Suite 207
Bryan, TX 77802

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Armstrong Laboratory
Human Resources Directorate
Manpower and Personnel Research Division
Brooks Air Force Base, TX 78235-5000

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
AL-TR-1992-0006

11. SUPPLEMENTARY NOTES
Armstrong Laboratory Technical Monitor: Larry Looper, (512) 536-3551.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
This research produced a prototype of an interdependent, multiple-job utility assessment system. The simulation utility management system (SUMS) prototype can be used to determine the effects of changes in manpower policy and programs on individual job and total system utility. The model development involved identifying appropriate costs associated with acquisition, training, maintenance, and separation of enlisted personnel and determining a dollar value of services rendered during a potential 30-year service tenure. The prototype includes major personnel programs used by the Air Force to access, train, upgrade, reenlist, and separate enlisted personnel. SUMS maximizes overall system utility through an optimal allocation of accessions, given the expected quality mix of the accession pool. The prototype was tested using data for four Air Force Specialties (AFSs) and determined system utilities resulting from six different personnel management scenarios: force drawdown, increasing minimum aptitude requirements, accession pool reduction, increasing the size of the force drawdown, imposing minimum manning requirements, and determining aptitude cutoff scores.

14. SUBJECT TERMS
Computer simulation model
Force analysis
Productive capacity
Productive value
Utility

15. NUMBER OF PAGES
52

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

CONTENTS

List of Tables

List of Tables (Concluded)

PREFACE

This research and development effort was accomplished as part of Project 7719, Force Acquisition and Distribution Systems and Task 771920, Manpower and Personnel Models. The purpose of this effort was to evaluate applicability of computer simulation modeling (CSM) to assessing the utility of Air Force personnel system components.

We wish to thank Dr. Bryan Deuermeyer, Mr. Vince Wiggins, Ms. Lavonne Grossmann, and Mr. Carlton Hubbard for their valuable technical contributions to this effort. In addition, we would like to express appreciation to Ms. Barbara Randall (computer programmer), Mr. Gary Petersen (systems analyst), and Mr. Daryl Hand (computer programmer).

A COMPUTER SIMULATION MODELING APPROACH TO ESTIMATING UTILITY IN SEVERAL AIR FORCE SPECIALTIES

SUMMARY

The objective of this research effort was to evaluate computer simulation modeling (CSM) as an alternative to traditional (algebraic) approaches for assessing human resource management (HRM) program utility. The research used recent work linking individual aptitude and experience to job performance to develop an interdependent multiple-job personnel utility assessment system.

A prototype model was developed using four Air Force Specialties (AFSs): 122X0 (Aircrew Life Support), 272X0 (Air Traffic Controllers), 426X2 (Jet Engine Mechanics), and 492X1 (Information Systems). The model development involved identifying appropriate costs associated with acquisition, training, maintenance, and separation of enlisted personnel and a dollar value of services rendered during a potential 30-year service tenure. The prototype includes major personnel programs used by the Air Force to access, train, upgrade, reenlist, and separate enlisted personnel.

The simulation utility management system (SUMS) prototype incorporates the CSM technology into a computer-based system to determine the effects of changes in manpower policy and programs on individual job and total system utility. SUMS maximizes overall system utility through an optimal allocation of accessions, given the expected quality mix of the accession pool.

INTRODUCTION

Utility analysis is a methodology often compared to cost/benefit analysis which is used to assess the value of HRM programs. Utility analysis can be defined as the determination of institutional gain or loss (outcomes) anticipated from various courses of resource management action (Cascio, 1982) or the assessment of the economic or social impact of organizational programs (Hunter & Schmidt, 1982). Boudreau (1988) indicates that utility analysis is a set of cost/benefit models originally developed by industrial psychologists concerned with personnel selection and recently extended to other HRM programs and decisions. The aim of these models is to predict, explain, and improve the usefulness of various HRM decisions.

Utility analysis can be traced back nearly 70 years (Hull, 1928; Kelley, 1923), but Brogden's (1949) and Cronbach and Gleser's (1965) developments laid the ground work for more recent elaborations (Schmidt, Hunter, McKenzie, & Muldrow, 1979). Original utility research focused on employee acquisitions. The traditional equation used for estimating the change in system utility, ΔU, developed by Brogden (1949) and further discussed by Cronbach and Gleser (1965) can be expressed as:

$$\Delta U=[(N)(T)(d_t)(SD_y)]-C \qquad (1)$$

where:

- N = number of employees subjected to the acquisition program, i.e., the selected cohort (treated group),
- T = mean length of stay,
- d_t = true difference in average job performance between the selected and selected groups in standard deviation units (Landy, Farr, & Jacobs, 1982),
- SD_y = the standard deviation of the dollar-valued payoff in the group of applicants, and
- C = cost of systematic selection for all tested applicants.

Traditional utility models have several limitations to their application to determine HRM program value to the military, some of which have already been identified. Traditional approaches to utility analysis (a) assume a linear (or transformable to linear) functional relationship, (b) seek algebraic solutions to utility estimates, (c) are limited to static, or at least stationary, processes, (d) have been limited to single job systems, and (e) have assessed the impact of HRM policies in dollar terms. The recent development of a Time-to-Proficiency (TTP) model (Carpenter, Monaco, & O'Mara, 1989) for one AFS addressed several of these shortcomings. The refined TTP model (Faneuff, Valentine, Stone, Curry, & Hageman, 1990) permits a longitudinal assessment of airman productive capacity and cost/benefit relations associated with training and attrition.

Simulation models use the computational power of computers to obtain estimates of system characteristics. CSM provides a viable alternative to assessing HRM program utility and is not subject to the limitations of conventional analytical utility models. CSM provides the opportunity for estimating system utilities simultaneously for multiple and interrelated (a) criterion variables, (b) productivity-enhancing HRM interventions, and (c) multiple job systems.

Computer simulation modeling of utility provides an alternative to traditional utility analysis, eliminating the need to estimate means for tenure, expected payoff, and differences in productivity for the entering cohort. In addition, CSM of utility accounts for the effect of training and acquisition programs on retention and separations, as well as provides a means to estimate the effect of other postacquisition and training programs on total system utility, e.g., selective reenlistment bonuses.

The mean length of stay, **T**, is the inverse of an accession cohort's simulated attrition rate over a selected time horizon. For example, a 25% attrition rate translates into a mean length of stay of 4 years, (1/0.25) = 4. This example implies that over the first 4 years of tenure, every entering cohort will lose 25% of its population. The actual difference in job performance, $\mathbf{d_t}$, is the difference in dollar productivity between the treated group and the control group in a simulation. The standard deviation in the dollar-valued payoff to be accrued from an entering cohort over the mean length of stay, $\mathbf{S\,D_y}$, is estimated by the simulation of dollar-valued productivity by the entering cohort for each projected time period. The cost of systematic selection for all test applicants, **C**, is reflected in the change in the acquisition/training costs for the system simulation. Thus, CSM of utility should provide more accurate estimates of the change in total system utility.

For this study, a SUMS was developed which employs CSM to model the flow of Air Force enlisted personnel, combined with cost and productive value estimates from the Value of Air Force Experience (VAFE) research effort (Stone, Rettenmaier, Saving, & Looper, 1989a) to assess a dollar-valued utility payoff for alternative HRM programs. The next section presents three primary components of SUMS: the personnel flow module, the accession allocation module, and the utility assessment module. Then a section describes the data sources used for the implementation of SUMS and provides examples of HRM program assessments using SUMS. The final section provides a brief conclusion and suggestions for future research and extension of SUMS.

CONCEPTUAL DEVELOPMENT OF SUMS

The development of SUMS is based on a methodology used for the assessment of HRM system utility initially presented by Boudreau and Berger (1985) as a multiple-cohort acquisition and retention utility model. This methodology results in a dollar-valued workforce utility for a given time horizon taking into account the quantity and quality of accessions, separations, and retentions in each of the time periods. SUMS employs this methodology in the calculation of total net utility for each specified simulation scenario. Thus, SUMS reflects parameters relevant to a fully integrated utility model which includes accession, training, upgradion, separation, and retention of personnel.

For each projected time period, total system utility is calculated based on productive capacity and costs which are affected by the quality and quantity of accessions, separations, and continuations. Changes in policy and/or personnel parameters can be assessed in terms of AFS-specific and/or total system utility, as well as tradeoffs between force structures composed of more/less experienced personnel.

SUMS is comprised of three primary components which provide the necessary information for the calculation of total system utility:

(1) Personnel Flow Module (PFM) - simulates flows within a multi-job system,

(2) Accession Allocation Module (AAM) - allocates accessions from a given accession pool across jobs, and

(3) Utility Assessment Module (UAM) - estimates a dollar utility value of the workforce across jobs.

Total system utility is only one of several measures (e.g., inventory levels, upgradions, separations, costs) provided by SUMS to evaluate the personnel flows and policies of the multi-job system.

Personnel Flow Module

The personnel flow module is a simulation flow model of an enlisted multi-job system with the capability to analyze any single or multiple combination of AFSs. The simulation model encompasses accessions, upgrades, and separations. Simulations extend over selected time horizons in years (e.g., 5 years). The simulation starts with an initial inventory of personnel which has to be aged, separated, and upgraded for each time period of the selected horizon. First, the inventory is separated using aptitude- and AFS-specific continuation rates. Secondly, the remaining population is upgraded in order to fill the vacancies created by the separations and maintained by the manning requirements. Thirdly, the accession goals are determined based on the remaining inventory and the manning requirements. Given the size and aptitude mix of the accession pool, accessions are allocated across AFSs in order to meet accession goals. The beginning inventory for each time period is comprised of the continuations and accessions from the previous time period.

SUMS has the capacity to simulate under various continuation (reenlistment/retention) scenarios, providing the user with policy parameters which can be initialized to represent personnel policy decisions and/or programs. Subgroups within the personnel inventory of an AFS can be defined by aptitude, year of service (YOS), and skill level. Each AFS uses one of the four composite scores from the Armed Services Vocational Aptitude Battery (ASVAB): mechanical, administrative, general, or electronic (MAGE) divided into ten levels of capability. The ten aptitude levels include scores within the ranges of 0 to 9, 10 to 19, 20 to 29, ..., 90 to 99. The skill levels represent the four AFS-specific skill levels which can be achieved: skill level 3 for semi-skilled, skill level 5 for skilled (journeyman), skill level 7 for advanced (technician), and skill level 9 for superintendent/manager. YOS includes 0 to 30 years of service.

Accession Allocation Module

SUMS allocates accessions to AFSs to fulfill AFS-specific manning vacancies caused by the attrition/promotion process and manning requirements. SUMS selects recruits from a given accession pool comprised of a given aptitude mix based on the

four ASVAB composite scores (mechanical, administrative, general, and electronic) and their designated cohorts. The allocation of aptitude-specific accessions to AFSs is performed using a methodology which maximizes the total net utility resulting from an allocation of aptitude-specific accessions to multiple AFSs. The AAM used in SUMS considers several factors: productive capacity, value of services produced by personnel in the Air Force (Stone et al., 1989a), probability of attrition, training costs, recruitment costs, and personnel maintenance costs (regular military compensation). These factors are combined into a single measure of expected net utility for any aptitude cohort in any AFS in SUMS.

AAM allocates accessions to the various AFSs such that the total net utility from the accession allocation is maximized. The expected net utility for an individual with aptitude **x** is defined simply as the difference between expected value and expected cost over 30 years of service. Thus, the objective function being maximized is the summation of expected net utility across all accessions allocated to all AFSs. To determine the allocation which maximizes total expected net utility for the system (across AFSs), a linear programming routine is used. This linear programming algorithm determines the number of individuals from each aptitude category to be assigned to each AFS across all AFSs specified in the system. The relative differences in the expected net utility accruable from the allocation of aptitude-specific accessions to specific AFSs directly affects the optimum accession allocation. The solution is obtained by maximizing:

$$\sum_{k=1}^{K} \sum_{x=1}^{M} (ENU_{x,k} \times n_{x,k}) \tag{2}$$

subject to:

$$\sum_{k=1}^{K} n_{x,k} \leq a_x \quad \text{for all } x \tag{3}$$

$$\sum_{x=1}^{M} n_{x,k} \leq r_k \quad \text{for all } k \tag{4}$$

$$n_{x,k} \geq 0 \quad \text{for all } x \text{ and } k \tag{5}$$

where:

x is the aptitude level,

M is the number of aptitude levels,

k is the kth AFS,

K is the number of AFSs,

$n_{x,k}$ is the number of accessions with aptitude **x** assigned to AFS **k**,

r_k is the accession requirement for AFS **k** which is necessary to meet the desired manning level,

$ENU_{x,k}$ is the expected net utility to be accrued to the system from allocating an accession with aptitude **x** to AFS **k**, and

a_x is the number of accessions of aptitude **x**.

The objective function (Equation 2) is the total expected net utility of all accessions assigned to all AFSs from all aptitude levels. The allocation problem is solved by finding the maximum value for this function. The first constraint expressed in Equation 3 is that the number of accessions assigned from an aptitude level cannot exceed the number of accessions available. The second constraint, Equation 4, is that no additional accessions will be assigned to an AFS once the established manning level has been met. However, if there is a manpower shortage, fewer accessions than required can be allocated to an AFS. The third constraint, Equation 5, simply specifies that a negative number of accessions with aptitude **x** cannot be assigned to an AFS.

To allocate accessions to the AFSs in SUMS, a measure of expected net utility, $ENU_{x,k}$, is required for the kth AFS. This value is estimated in three steps: estimation of expected value, estimation of expected costs, and estimation of expected net utility.

Estimation of Expected Value

The expected value for an individual with aptitude **x** equals the summation over 30 years of service of the products of the probability that an individual with aptitude **x** will remain in service through YOS **e** multiplied by the value accruing to the Air Force of an individual with aptitude **x** in YOS **e** multiplied times the productive capacity (Faneuff et al., 1990) of an individual with aptitude **x** in YOS **e**. The expected value of an individual with aptitude **x** over 30 years of service, EV_x, can be expressed as:

$$EV_x = \sum_{e=0}^{30} [S_{x,e} \times V_{x,e} \times P_{x,e}] \qquad (6)$$

where:

$S_{x,e}$ is the probability that an individual with aptitude **x** will remain in service through YOS **e**,

$V_{x,e}$ is the value to the Air Force of the services provided by an individual in YOS **e**, and

$P_{x,e}$ is the productive capacity of an individual with aptitude **x** in YOS **e**.

Estimation of Expected Cost

The expected cost of an individual with aptitude **x** over 30 years of service, EC_x, equals the summation over 30 years of service of the products of the probability that an individual with aptitude **x** will remain in service through YOS **e** multiplied by the cost to the Air Force of an individual with aptitude **x** in YOS **e** (Faneuff et al., 1990), which can be expressed as:

$$EC_x = \sum_{e=0}^{30} [S_{x,e} \times C_{x,e}] \tag{7}$$

where:

$C_{x,e}$ is the cost to the Air Force of maintaining and/or training an individual with aptitude **x** in YOS **e** and

$S_{x,e}$ is the same as in Equation 6.

Estimation of Expected Net Utility

Thus, the expected net utility of an individual with aptitude **x** over 30 years of service, ENU_x, is the difference between expected value and expected cost over 30 years of service and can be expressed as:

$$ENU_x = EV_x - EC_x \tag{8}$$

or

$$ENU_x = \sum_{e=0}^{30} [S_{x,e} \times V_{x,e} \times P_{x,e}] - \sum_{e=0}^{30} [S_{x,e} \times C_{x,e}] \qquad (9)$$

The probability an individual will remain in service through YOS e declines as e increases. Higher aptitude individuals exhibit lower probabilities of prematurely separating from service during the first 4 years, but are more likely to separate at the first and second term decision points (Stone, Looper, & McGarrity, 1989b). Productive capacity is directly related to aptitude and experience (Carpenter et al., 1989 and Faneuff et al., 1990). Thus, differences in expected net utility by aptitude are primarily due to differences in productive capacity and attrition rates. Differences in expected net utility by AFS are due to differences in service value, productive capacity, and attrition rates.

Utility Assessment Module

The utility assessment module calculates the dollar-valued workforce utility for the total system resulting for each of the projected time periods. The dollar-valued workforce utility accounts for both the quantity and quality of accessions, continuations, and separations which occur in each projected time period considering both value and costs generated by the workforce.

SUMS accesses, promotes, and separates personnel of a specified quantity/ quality-defined workforce where quality is defined by the mix of four ASVAB composite scores of the workforce and the accession pool. The calculation of total system utility includes value produced and costs incurred by new accessions, separations, and continuations. To facilitate understanding of the total system utility calculation, the formulation of each component will be presented and then combined into the total estimate.

The contribution to total system utility of new accessions for a single time period, $U_{a,t}$, can be expressed as:

$$U_{a,t} = 0.5 \times \sum_{x=1}^{M} [N_{a,t,x,e} \times (V_{a,t,x,e} - C_{a,t,x,e})] \qquad (10)$$

where:

$N_{a,t,x,e}$ equals the number of accessions in time period **t** of aptitude **x** with experience **e=0**,

$V_{a,t,x,e}$ equals the value of accessions in time period t of aptitude x with experience e=0,

$C_{a,t,x,e}$ equals the cost of accessions in time period t of aptitude x with experience e=0, and

M equals the number of aptitude groups.

The value of the accessions, $V_{a,t,x,e}$, in time period t of aptitude x with experience e equal to 0 is defined as:

$$V_{a,t,x,e}=S_{t,x,e}\times V_{t,x,e}\times P_{t,x,e} \tag{11}$$

where:

$S_{t,x,e}$, $V_{t,x,e}$, and $P_{t,x,e}$ are as defined in Equation 6 and e takes the value of 0 for the first YOS. The multiplication of total net utility for new accessions by 0.5 implies that the costs and values are assumed to be spread evenly over the time period. If accessions predominantly flow into the system in the earlier part of the time period, then the 0.5 is not a good approximation.

The contribution to total system utility of separations for a single time period, $U_{s,t}$, can be expressed as:

$$U_{s,t}=0.5\times\sum_{e=0}^{30}\sum_{x=1}^{M}[N_{s,t,x,e}\times(V_{s,t,x,e}-C_{s,t,x,e})] \tag{12}$$

where:

$N_{s,t,x,e}$ equals the number of separations in time period t with aptitude x and YOS e,

$V_{s,t,x,e}$ equals the value of separations in time period t with aptitude x and YOS e, and

$C_{s,t,x,e}$ equals the cost of separations in time period t with aptitude x and YOS e.

The multiplication of total net utility for separations by 0.5 implies, once again, that the costs and values accrued from separations are assumed to be spread evenly over the time period t.

The contribution to total system utility of airmen identified as continuations for a single time period, $U_{c,t}$, can be expressed as:

$$U_{c,t}=\sum_{e=0}^{30}\ \sum_{x=1}^{M}[N_{c,t,x,e}\times(V_{c,t,x,e}-C_{c,t,x,e})] \tag{13}$$

where:

$N_{c,x,t,e}$ equals the number of continuations in time period **t** with aptitude **x** and YOS **e**,

$V_{c,x,t,e}$ equals the value of the continuations in time period **t** with aptitude **x** and YOS **e**, and

$C_{c,x,t,e}$ equals the cost of the continuations in time period **t** with aptitude **x** and YOS **e**.

Thus, total system utility for a single time period **t**, U_t, is defined as:

$$U_t=(0.5\times\sum_{x=1}^{M}[N_{a,t,x}\times(V_{a,t,x}-C_{a,t,x})])+(0.5\times\sum_{e=0}^{30}\ \sum_{x-1}^{M}[N_{s,t,x,e}\times(V_{s,t,x,e}-C_{s,t,x,e})]) \tag{14}$$

$$=\sum_{e=0}^{30}\ \sum_{x=1}^{M}[N_{c,t,x,e}\times(V_{c,t,x,e}-C_{c,t,x,e})]$$

or

$$U_t= U_{a,t}+ U_{s,t}+ U_{c,t}. \tag{15}$$

For multiple time periods, discounting is used to account for the future value of money (Stone et al., 1989a). If Equation 15 is represented by U_t, then total system utility for T time periods, U_T, can be expressed as:

$$U_T = \sum_{t=1}^{T} \frac{U_t}{(1+r)^t} \qquad (16)$$

where r is the discount rate. Thus, Equation 16 represents the discounted, net of cost, dollar-valued workforce utility in future time periods 1 through T taking into account the quantity and quality of acquisitions, separations, and retentions in those future periods (Boudreau & Berger, 1985).

SIMULATION USING SUMS

This section will describe the data sources used for the implementation of SUMS, present several examples of analyzing particular personnel and policy issues using SUMS, and highlight the potential of SUMS for other analyses. Values and costs were estimated for each AFS in the scenarios using information from Air Force personnel data bases, Bureau of Census population surveys, and various Air Force regulations and published documents.

Data Development

In previous research, grade and skill level were used as the criteria for the definition of service states (Stone et al., 1989a). For the present examples using SUMS, YOS was used as the basis for service states. Each YOS from 0 to 30 represents a service state. In the calculation of formal and informal training, skill level was used as a secondary criteria in determining the appropriate service state training costs.

Service State Costs

The source for the dollar costs of recruitment, basic military training (BMT), and formal technical training was the Air Training Command's FY88 Cost Factors Manual (1988). All costs were estimated or allocated by YOS. Acquisition costs which include recruitment and BMT are not considered to be AFS-specific while technical training and on-the-job training (OJT) varied by AFS. The information provided in the Air Training Command's FY88 Cost Factors Manual (1988) provided technical training course costs for each AFS. These costs were used in conjunction with information from the (ORDB) concerning courses taken by airmen at specific stages of their career to estimate the costs of formal technical training for each AFS by YOS (Longmire & Short, 1989). The technical training costs allocated to each YOS were estimated as a weighted average based upon the proportion of individuals who had taken a course in each YOS (Stone et al., 1989a).

OJT was estimated primarily for individuals in skill levels 3 and 5; i.e., those individuals with the rank of either E-2, E-3, or E-4 and with a skill level of 3 (semi-

skilled) or 5 (skilled). Since minimal OJT occurs beyond skill level 5, no OJT costs beyond that level were included. To estimate the level of OJT which individuals received while in these two skill levels, data from the ORDB were analyzed to provide an estimate of the relationship between time in service and proficiency. The approaches used to estimate the OJT costs and supervisor costs were the same as that used by Stone et al., (1989a).

Military compensation was comprised of basic pay, basic allowance for quarters (BAQ), basic allowance for subsistence (BAS), and the tax advantage accruing from the nontaxable nature of BAQ and BAS. Military compensation also accounted for promotion rates by AFS determined from the June 1985 and June 1986 Uniform Airman Records (UARs).

Service State Values

The value to the Air Force of the services provided by an individual in YOS **e** was based on the civilian earnings surveys administered monthly by the Bureau of the Census (U.S. Department of Commerce, 1986). The civilian earnings represents the opportunity cost to the airman of remaining in the service, i.e., income which the airman could have made in the private sector for providing similar services (Stone et al., 1989a). The survey respondents were categorized by individual AFSs. AFS-specific earnings were then estimated based on age, e.g.,

$$\text{earnings} = a_0 + a_1(\text{age}) + a_2(\text{age}^2). \tag{17}$$

The service values estimated for each YOS assumed that the average age at enlistment was 18. Thus, an age-earnings function was estimated for each AFS used in SUMS which represents the value to the Air Force of a recruit entering an AFS at age 18 and progressing through 30 years of service.

Continuation Rates and Probabilities. The UARs in the Historical Airman Data (HAD) base (Saving, Stone, Looper, & Taylor, 1985) were used to estimate the probability of an individual with aptitude **x** continuing from one YOS to another. To calculate the continuation rates for the enlisted AFSs, data were obtained from the UAR files for June 1985 and June 1986. The June 1985 to June 1986 time period was selected because that time period was before enlisted force drawdowns had begun to reach sizeable numbers in fiscal year 1986 (Stone, Saving, Turner, Looper & Engquist, 1991). Since SUMS provides the ability to specify a force/AFS drawdown, the continuation rates used should reflect airman decision-making absent of force-outs caused by a force reduction program. Continuation rates were calculated by YOS, AFS, and aptitude. To obtain AFS specific rates which varied by aptitude, continuation rates were calculated at the 2-digit level, e.g., 27XXX for AFS 272X0. At the 5-digit AFS level aptitude group sizes were very small, especially for the low

aptitude groups. By estimating at the 2-digit AFS level, cell sizes were large enough to use with reliability in the model.

Once the continuation rates were estimated, the probability that an individual with aptitude **x** will remain in service through YOS **e** was calculated as the product of all probabilities (continuation rates) prior to YOS **e**. For example, if the continuation rates for individuals with aptitude **x** for YOSs 0, 1, 2, and 3 were 0.85, 0.90, 0.90, 0.85, respectively, then the probability that an individual with aptitude **x** will remain in service through YOS 3 is the product of $(0.85 \times 0.90 \times 0.90 \times 0.85)$, which equals 0.5852. The probability that an individual with aptitude **x** will remain in service through YOS **e** is used in the calculation of expected net utility in the allocation module.

Productivity. Data from the Air Force Job Performance Measurement (JPM) research program for each of the four AFSs included in SUMS were used to estimate the productive capacity of an individual with aptitude **x** in YOS **e**. JPM's Walk-Through Performance Interview - Phase I Test score was used (Hedge, 1984). The interview test score of the jth individual, T_j, was divided by the standard level of productivity for an individual in the career field, T^*, to determine productive capacity, P_j, as shown below:

$$P_j = \frac{T_j}{T^*} \qquad (18)$$

where:

T_j is the interview test score for the jth individual

T^* is the interview test score for the 75th percentile.

T^* was based on the T_j value which approximately 75% of the 3 and 5 skill level respondents had. Productive capacity ranged between 0 and 2, though most productive capacity values were smaller than 1.2. Thus, the estimate of T^* represented the productivity level at the 75th percentile.

The relationship between the productive capacity measure, aptitude, and experience formed the basis for the productive capacity estimates used for each AFS. Using the interview test score data for each of the four AFSs, productive capacity equations were estimated using:

$$P_{j,k} = b_0 + b_1 e_{j,k} + b_2 x_{j,k} \qquad (19)$$

where:

$P_{j,k}$ is the productive capacity measure for the jth individual in AFS k,

$e_{j,k}$ is YOS (experience) for the jth individual in AFS k, and

$x_{j,k}$ is aptitude for the jth individual in AFS k.

Equation 19 was estimated for each AFS using ordinary least squares and provides an estimate of productive capacity for any individual j in AFS k with aptitude x and YOS (experience) e. In addition to the explanatory variables presented, the intercept was computed to account for the variation in productive capacity occurring within AFSs due to differences in raters and bases. A summary of the coefficients, t-values, number of observations, and R-squared is found in Table 1.

TABLE 1. OLS COEFFICIENTS AND T-VALUES FOR THE FOUR PRODUCTIVE CAPACITY EQUATIONS

Variable/AFS (Aptitude Score)	122X0 (General)	272X0 (General)	426X2 (Mechanical)	492X1 (Administrative)
TAFMS (Total Active Federal Military Service)	0.0084 (4.792)*	0.0032 (2.110)	0.0035 (2.812)*	0.0062 (3.649)*
Aptitude Score	0.0006 (0.541)	0.0025 (2.655)*	0.0047 (5.767)*	0.0009 (0.616)
Number of Observations	171	172	197	126
R-square	0.4435	0.2772	0.4200	0.2530

*Statistically significant at the .01 level.

Experience (TAFMS) was found to be statistically significant in three of the four equations while aptitude was statistically significant in two.

Initial Specification of SUMS

SUMS includes numerous policy and personnel parameters which can be modified to allow a wide range of "what-if" scenarios. For a detailed discussion of how the user initializes and operates SUMS refer to the Appendix. Several of the parameters modified in this section were changed sequentially in the six scenarios that follow to demonstrate SUMS' capability to address the effects of policy and personnel system changes, as well as to provide an overview of the analytical capabilities of SUMS. The scenarios are:

(1) baseline,

(2) increase in the minimum aptitude score required for an entering accession in each AFS,

(3) reduction in the size of the accession pool,

(4) increase the size of the force drawdown in year 2,

(5) impose minimum manning requirements for each AFS and reduce the accession pool, and

(6) determine the optimal aptitude cut-off scores for each AFS for entering accessions.

The values for each scenario can be found in Table 2.

TABLE 2. SCENARIO SEQUENCE

Scenario	Minimum Aptitude	Accession Pool	Minimum Manning	Force Drawdown in Year 2
Baseline	40	1300	0%	10%
1	50	1300	0%	10%
2	40	1170	0%	10%
3	40	1300	0%	25%
4	40	1170	85%	10%
5	Determine	1300	0%	10%

Other factors which will remain constant throughout the simulation and discussion are:

(1) The analysis involves four career fields:

Number	Description	Relevant Composite
122X0	Aircrew Life Support	General
272X0	Air Traffic Control	General
426X2	Jet Engine Mechanic	Mechanical
492X1	Information Systems	Administrative

(2) Two-year projections are simulated beginning in 1990,

(3) the accession aptitude mix applied to each projected year's accession pool is constant. The actual FY89 Air Force Military Entry Processing Stations (MEPS) applicant file was used as the basis for estimating the aptitude mix for each of the 2 projected years,

(4) the beginning inventory and manning goals for each career field for each projection year by skill level remain the same and are presented in Table 3. The manning goals are decreased in Year 2 by approximately 10% across skill levels and across AFSs with the exception of example 3 which simulates a 20% manning reduction,

(5) upgrade proportions are set at 1.0 across all skill levels and AFSs. The 1.0 upgrade proportion implies that no individual in a YOS group will be passed over for upgrade if he/she meets the minimum YOS criteria for that skill level,

(6) force out proportions are set at 1.0 across all skill levels and AFSs. The 1.0 force out proportion implies that 100% of the personnel necessary to reduce the overage in a skill level will be forced out of service,

(7) the minimum years of service for upgrade are 1 year for skill level 3 to 5, 6 years for skill level 5 to 7, and 16 years for skill level 7 to 9, and

(8) all costs are assumed to increase by 5% per projection year though regular military compensation (RMC) wage will increase by 4.1% per year.

TABLE 3. INVENTORY AND MANNING LEVELS

	Skill Levels				
	3	5	7	9	Total
122X0					
Initial Inventory	121	720	386	46	1,273
Manning Goals (Year 1)	120	720	385	50	1,275
Manning Goals (Year 2)	108	648	347	45	1,148
272X0					
Initial Inventory	249	1,218	1,105	173	2,745
Manning Goals (Year 1)	250	1,220	1,105	175	2,750
Manning Goals (Year 2)	234	1,097	995	158	2,484
426X2					
Initial Inventory	488	1,842	947	127	3,404
Manning Goals (Year 1)	490	1,840	950	125	3,405
Manning Goals (Year 2)	441	1,656	855	113	3,065
492X1					
Initial Inventory	145	579	340	34	1,098
Manning Goals (Year 1)	145	580	340	35	1,100
Manning Goals (Year 2)	131	522	306	31	990

Baseline - Force Drawdown

The total system utility (see Table 4) accruing to the personnel system in Year 1 was approximately $87.8 million, which is the SUMS productivity estimate from a population of 8,525 enlisted personnel in the four AFSs. The dollar value of utility should only be used for comparison to other simulation utility values and not as an actual dollar value. Table 5 presents the Baseline scenario simulation results for Year 1 which is prior to the force drawdown in Year 2. The only manning shortage in Year 1 occurred in AFS 492X1. Total recruits accessed in Year 1 were 1,221. Based on the relative net utilities presented in Table 6, AFSs 122X0 was the only AFS to not be allocated accessions with aptitudes above 69, see Table 7. Because of the low net utility values for high aptitude accessions for AFS 122X0, all the high aptitude accessions were assigned to the other AFSs. Only at aptitude level 60 did AFS 122X0 have a net utility value of any magnitude and therefore accessions came in at this level.

TABLE 4. UTILITY

Year	Total Population	Total Cost	Total Value	Net Utility
0	8,520			
1	8,525	$220,575,680	$308,421,120	$87,845,440
2	7,680	215,633,728	311,074,560	95,440,832

Year 2 results are presented in Table 8. Forced separations were required in two of the four AFSs, 122X0 and 426X2, to meet the 10% force reduction. Accessions for Year 2 dropped approximately 73.9% from Year 1 to 319 total accessions. Though the total enlisted force fell from 8,525 to 7,680, the total system net utility rose over 8.6% from the previous year to approximately $95.4 million (see Table 4). This dramatic rise in total system utility is due to the reduced training costs of accessing fewer but higher aptitude recruits and the higher productivity of a more experienced work force. In fact, even with the 10% reduction in the total force, total value increased by $2.65 million with a smaller force. The fewer-in-number but higher-in-aptitude recruits for Year 2 more than offset the loss in productivity due to separations and a smaller number of accessions. This implies that a more experienced force with higher aptitude recruits can potentially offset the loss in productivity due to a smaller force. Also, it can be noted from Table 6, the relationship between aptitude and utility is nonlinear.

Scenario 1: Increasing Minimum Aptitude Requirements

Scenario 1 examined the effects of a change in the minimum aptitude requirements for entering a career field. The specifications of the previous example were maintained with the exception that minimum aptitude requirements were increased from 40 to 50 for each of the career fields based on the relevant composite score. The change in the aptitude requirements did not significantly affect the flow of personnel through three of the AFSs, but AFS 122X0 experienced a shortage as the result of the change in aptitude requirements. In the Baseline example, approximately 21% of the accessions allocated to AFS 122X0 were from the aptitude group with scores between 40 and 49. The higher aptitude requirements eliminated this potential pool of accessions for AFS 122X0, as well as for the other AFSs. Without this potential pool of accessions, the remaining eligible pool was reallocated among the four AFSs. Due to the relative net utilities exhibited in Table 6, higher aptitude accessions were once again allocated to AFSs 272X0, 426X2, and 492X1, leaving AFS 122X0 approximately 42% short of its accession goal. The accession flow of Year 2 (393) was sufficiently small to be unaffected by the increased aptitude requirements. Given the large accession pool (1,300 applicants) relative to the accession goal, the allocation of accessions to each AFS by aptitude was not affected in Year 2.

TABLE 5. SIMULATION RESULTS FOR A 2-YEAR PROJECTION: YEAR 1

	Skill Levels 3	5	7	9	Total
122X0					
Manning Goals	120	720	385	50	1,275
Initial Inventory	121	720	386	46	1,273
Separations	16	138	31	17	203
Upgrades	0	105	51	21	177
Accessions	205	0	0	0	205
Forced Outs	0	0	0	0	0
Shortage (Overage)	85	-85	0	0	0
Ending Inventory	205	635	385	50	1,275
272X0					
Manning Goals	250	1,220	1,105	175	2,750
Initial Inventory	249	1,218	1,105	173	2,745
Separations	27	209	108	32	375
Upgrades	0	222	142	34	398
Accessions	380	0	0	0	380
Forced Outs	0	0	0	0	0
Shortage (Overage)	130	-130	0	0	0
Ending Inventory	380	1,090	1,105	175	2,750
426X2					
Manning Goals	490	1,840	950	125	3,405
Initial Inventory	488	1,842	947	127	3,404
Separations	48	353	67	29	499
Upgrades	0	440	98	27	565
Accessions	499	0	0	0	499
Forced Outs	0	0	0	0	0
Shortage (Overage)	9	-9	0	0	0
Ending Inventory	499	1,831	950	125	3,405
492X1					
Manning Goals	145	580	340	35	1,100
Initial Inventory	145	579	340	34	1,098
Separations	13	87	35	6	140
Upgrades	0	129	41	7	177
Accessions	137	0	0	0	137
Forced Outs	0	0	0	0	0
Shortage (Overage)	-5	0	0	0	-5
Ending Inventory	140	580	340	35	1,095

TABLE 6. NET UTILITY FOR APTITUDE GROUPS BY AFS

AFS	Aptitude	Value	Cost	Net Utility
	90	$103,303	$ 96,718	$ 6,586
	80	128,792	108,920	19,872
	70	122,810	106,084	16,725
	60	146,582	122,363	24,219
122X0	50	110,929	100,509	10,421
	40	124,004	106,420	17,584
	30	113,307	103,976	9,332
	20	8,818	8,037	781
	10	8,790	8,037	753
	90	141,428	103,744	37,685
	80	152,672	110,269	42,404
	70	159,761	113,397	46,365
	60	139,181	99,900	39,282
272X0	50	135,106	98,262	36,844
	40	138,793	99,608	39,185
	30	141,085	101,685	40,400
	20	13,024	8,037	4,988
	10	13,024	8,037	4,988
	90	140,935	105,665	35,271
	80	140,156	105,216	34,940
	70	137,840	104,313	33,527
	60	132,345	100,264	32,081
426X2	50	127,521	96,927	30,595
	40	128,529	98,141	30,388
	30	128,155	98,576	29,579
	20	113,364	87,409	25,955
	10	104,416	79,634	24,782
	90	114,755	105,133	9,623
	80	130,971	118,184	12,787
	70	102,256	97,074	5,183
	60	115,584	105,714	9,871
492X1	50	117,081	107,753	9,329
	40	118,943	108,425	10,518
	30	133,709	121,407	12,303
	20	116,011	105,973	10,038
	10	9,193	8,037	1,156

TABLE 7. ACCESSIONS BY APTITUDE FOR A 2-YEAR PROJECTION

	Aptitude								
Year	90	80	70	60	50	40	30	20	10
122X0									
91	0	0	0	161	0	43	0	0	0
92	0	0	0	50	0	0	0	0	0
272X0									
91	0	87	185	0	41	67	0	0	0
92	0	0	83	0	0	0	0	0	0
426X2									
91	74	104	93	103	59	67	0	0	0
92	106	29	0	0	0	0	0	0	0
492X1									
91	3	39	16	23	25	31	0	0	0
92	0	52	0	0	0	0	0	0	0

This reallocation of accessions caused the total system net utility to increase in Year 1 and decrease in Year 2 relative to the Baseline. The increase in Year 1 was largely a result of reduced training costs due to a fewer number of accessions. The decrease in Year 2 was only 0.1% compared to Year 2 of the Baseline scenario, i.e., little or no change. As in the Baseline scenario, the total system net utility increased approximately 7.7% from Year 1 to Year 2, implying once again, that a more experienced force with higher aptitude recruits can more than offset the loss in productivity due to a smaller force. Thus, increasing minimum aptitude requirements reduces the eligible accession pool which could potentially lead to shortages. In addition, increased minimum aptitude requirements affect total system net utility through the increased productivity of higher aptitude accessions and a higher aptitude force, reduced training costs of accessing fewer recruits, and higher separation costs as a result of higher attrition rates for higher aptitude personnel.

TABLE 8. SIMULATION RESULTS FOR A 2-YEAR PROJECTION: YEAR 2

	Skill Levels 3	5	7	9	Total
122X0					
Manning Goals	108	648	347	45	1,148
Initial Inventory	206	635	385	50	1,275
Separations	8	125	26	15	175
Upgrades	0	138	0	10	148
Accessions	50	0	0	0	50
Forced Outs	0	0	2	0	2
Shortage (Overage)	0	0	0	0	0
Ending Inventory	108	648	347	45	1148
272X0					
Manning Goals	225	1,098	995	158	2,476
Initial Inventory	380	1,090	1,105	175	2,750
Separations	32	190	96	39	357
Upgrades	0	205	8	22	235
Accessions	83	0	0	0	83
Forced Outs	0	0	0	0	0
Shortage (Overage)	0	0	0	0	0
Ending Inventory	225	1,098	995	158	2,476
426X2					
Manning Goals	441	1,656	855	113	3,065
Initial Inventory	499	1,830	950	125	3,405
Separations	30	338	60	31	460
Upgrades	0	164	0	19	183
Accessions	135	0	0	0	135
Forced Outs	0	0	15	0	15
Shortage (Overage)	0	0	0	0	0
Ending Inventory	441	1,656	855	113	3,065
492X1					
Manning Goals	131	522	306	32	991
Initial Inventory	140	580	340	35	1,095
Separations	9	97	39	12	157
Upgrades	0	53	14	9	75
Accessions	52	0	0	0	52
Forced Outs	5	8	10	0	23
Shortage (Overage)	0	0	0	0	0
Ending Inventory	131	522	306	32	991

Scenario 2: Reducing the Accession Pool

The size of the accession pool not only affects the allocation of accessions but also determines the level of productivity since productivity is a function of aptitude and experience. The accession pool for Scenario 2 was decreased by 10% to 1,170, with the aptitude distribution within the accession pool remaining the same. In Year 1, the primary effect of a smaller accession pool was the inability to attain accession goals. AFSs 122X0 and 492X1 experienced shortages of 74 and 49 people, respectively. These shortages were mitigated in Year 2 with the reduction in force level requirements.

As compared to the Baseline scenario, total system net utility rose approximately 1.1% in Year 1 and decreased 0.1% in Year 2. The increased utility in Year 1 was due to the shortage of personnel which reduced training costs relatively more than it reduced productivity. Since BMT training costs affected only first year accessions and first year accessions did not contribute significantly to force productivity, the loss in value was more than offset by the reduction in training costs. The decrease in Year 2 was only 0.1% compared to Year 2 of the Baseline scenario, i.e., little or no change. As in the Baseline scenario, the total system net utility increased approximately 7.3% from Year 1 to Year 2, implying once again, that a more experienced force with higher aptitude recruits can more than offset the loss in productivity due to a smaller force.

Scenario 3: Force Drawdown of 25%

Scenario 3 increased the force drawdown in Year 2 of the Baseline scenario to 25%. The results for Year 1 are exactly identical to the Baseline results for Year 1. In Year 2, the 25% force drawdown caused forced separations in all of the AFSs while only two AFSs exhibited forced separations in the Baseline scenario. In the Baseline scenario only 17 airmen were forced to separate, while 978 forced separations occurred in Scenario 3. In addition, 319 accessions were allocated in Year 2 of the Baseline scenario while no accessions were allocated in Scenario 3.

Total system net utility decreased approximately 8.6% in Year 2 from the Baseline scenario to Scenario 3. Both value and cost declined in the Year 2 of Scenario 3 as total system net utility decreasing by 0.7%. Whereas the more experienced workforce of the Baseline scenario with its higher aptitude recruits more than offset the loss in productivity due to a smaller force, the Scenario 3 decrease in the size of the workforce was too large to be offset. Thus, experience and higher aptitude recruits can offset losses in productivity from force reductions but there is a limit to the extent that the tradeoff remains favorable for total system net utility.

Scenario 4: Minimum Manning Requirements

To ensure that each career field is able, at least partially, to meet its desired accession goal, SUMS provides the ability to state desired minimum manning levels.

goals, the accessions will be allocated to the AFSs in order to maximize total system net utility, and, thus, the minimum manning levels will not affect the allocation of accessions or total system net utility. If minimum aptitude requirements restrict the available pool below the number required to fulfill recruiting goals, SUMS will perform a constrained maximization of total system net utility subject to the minimum manning goals across AFSs. Minimum manning requirements were established at 85% across the four AFSs. Thus, if the accession goal for AFS 272X0 is 209, then SUMS will attempt to access at least 177 recruits for AFS 272X0, as well as 85% of the desired accession goals across all other AFSs.

In addition, the accession pool was reduced by 10% from 1,300 to 1,170. With the accession pool at 1,300, the results exactly replicate the Baseline scenario because the shortage which occurred did not cause the AFS to fall below the minimum manning requirement of 85%. For this reason an accession pool size of 1,170 was used to illustrate the effects of minimum manning requirements on total system net utility. This scenario is comparable to Scenario 2 which assumed a 10% reduction in the accession pool.

The key difference between Scenario 2 and Scenario 4 in Year 1 occurred in the allocation of accessions across AFSs. In Scenario 2, only two of the AFSs exhibited shortages, 74 for AFS 122X0 and 49 for AFS 492X1. Since manning requirements were met first, shortages were spread among three of the four AFSs in Scenario 4: 31 for AFS 122X0, 71 for AFS 426X2, and 21 for AFS 492X1. The total force experienced a shortage of 123 accessions in both scenarios. The total system net utility for Year 1 decreased from Scenario 2 to Scenario 5 by slightly less than 0.6%, which resulted from the less than optimal allocation of accessions caused by the minimum manning requirements.

Year 2 for both scenarios showed similar results to the Year 1 comparison. Thus, imposing minimum manning requirements leads to less than optimal allocations of accessions as measured by total system net utility. The higher the level at which minimum manning requirements are established the more likely a less than optimal allocation of accessions will occur and the greater the impact on total system net utility.

Scenario 5: Establishing Aptitude Cutoff Scores

Scenario 5 is identical to the Baseline scenario with the exception that the allocation module of SUMS was allowed to establish the optimal aptitude cutoff scores given the aptitude mix and size of the accession pool. The allocation module is not restricted by a minimum aptitude score when allocating accessions among AFSs. In this scenario the "cutoff score" established for an AFS is determined by the lowest aptitude accession allocated to that AFS. This "cutoff score" for each AFS is only relevant for the accession pool used in determining the "cutoff score." In other words, given a different aptitude mix and size accession pool the "cutoff score" would be different.

The key factor in determining the cutoff score for an AFS is the expected net utility for accessions with aptitude **x**. As discussed in the previous section, the expected net utility used in SUMS is discounted over 30 years of service accounting for productivity, attrition, value, and cost. In the expected net utilities presented in Table 6, the variation in expected net utility by aptitude is caused by two key factors: productivity and probability of continuation from YOS **e** to YOS **e+1**. In the example presented in Table 6, value and cost within an AFS do not vary by aptitude, only by YOS. As discussed earlier, productivity is directly related to aptitude, i.e., for a given level of experience (years of service), **e**, as aptitude, **x**, increases productivity, $P_{x,e}$, rises. If productivity were the only factor which affected expected net utility, then expected net utility would always increase with aptitude.

Of course, the other key factor in the expected net utility calculation, is the probability of continuation from YOS **e** to YOS **e+1**. Continuation rates were estimated that accounted for variations by AFS and aptitude. Different continuation rates were observed for each decile of aptitude. For example, expected net utility for AFS 122X0 increases from aptitude group 90 to aptitude group 80, decreases from aptitude group 80 to aptitude group 70, increases from aptitude group 70 to aptitude group 60, decreases from aptitude group 60 to aptitude group 50, etc. Obviously, attrition is not always directly or inversely related to aptitude but changes throughout the whole range of aptitude. Similar patterns are exhibited by AFSs 272X0 and 492X1 in Table 6 while AFS 426X2 exhibits a consistent downward trend in expected net utility. With the variations in expected net utility exhibited by AFSs 122X0, 272X0, and 492X1, it would not be surprising to find the accession allocation module allocating accessions from lower aptitude groups, if necessary, to fulfill accession goals.

In Year 1, a cutoff score of 40 on the relevant composite was established for AFS 122X0, while scores of 30 were established for AFSs 272X0 and 426X2. AFS 492X1 had a low score of 20 established as its cutoff. In Year 2, the established cutoff scores rose dramatically due to the fall in the accession goals from 1,225 to 316 resulting from the 10% force reduction. This implies that cutoff scores only become an issue when accession goals are sufficiently high relative to the accession pool to require consideration of recruits with low aptitude scores. Year 1 is an example of a relatively high accession goal compared to the available accession pool. The system can either incur the consequences of manning shortages and high aptitude requirements as in Year 1 of the Baseline scenario or accept lower quality recruits in some AFSs and no manning shortages as in Year 1 of Scenario 5.

The total system net utility decreased by 0.06% in Year 1 between the Baseline scenario and Scenario 5. Total value increased in Year 1 by only 0.01% between the Baseline scenario and Scenario 5 while costs rose by approximately 0.04% due to the higher training costs associated with more accessions. In addition, the fall in total system net utility between the Baseline scenario and Scenario 5 for Year 1 can be considered a short-run phenomenon. Since the accession allocation module is

maximizing expected total system net utility over 30 years of service, the equilibrium position for the system will be established at a higher total system net utility than if the minimum aptitude requirements of the Baseline scenario are maintained. The expected net utility values used to optimize the allocation of recruits were based on the same continuation rates which caused separations and losses by YOS, AFS, and aptitude group and, thus, affected the value calculated for total system net utility.

CONCLUSIONS AND RECOMMENDATIONS

SUMS is a prototype developed to provide manpower managers and policy makers with a tool to analyze the effects of manpower decisions and personnel policy on the career field specific and overall system utility. SUMS utilizes research across several areas: economic and econometric analysis of accession and retention (Stone et al., 1989b), human resource accounting applications (Stone et al., 1989a), and utility analysis (Boudreau & Berger, 1985). SUMS combines the methodologies of these areas of research with the inventory flow aspects of the Air Force enlisted personnel system, accession, upgrade, separation, and continuation, to assess a dollar payoff for alternative HRM programs.

Conclusions

The scenarios presented in this report provided several conclusions:

1. A more experienced force with higher aptitude recruits can more than offset the loss in productivity due to a smaller force.

2. Increasing minimum aptitude requirements reduces the eligible accession pool, which could contribute to potential shortages, and indirectly affects total system net utility through increased productivity of entering accessions, reduced training costs, etc.

3. Within a limited range, reduction of the size of the available accession pool can lead to shortages (whether as a function of accession pool characteristics or user specified minimum aptitude cutoff scores), but once again, a more experienced force with higher aptitude recruits can offset the loss in productivity due to a smaller force.

4. Losses in productivity due to increased force reductions can be offset with a more experienced workforce and higher aptitude recruits, but there is a limit to the extent to which the tradeoff remains favorable for total system net utility.

5. Imposing minimum manning requirements leads to less than optimal allocations of accessions as measured by total system net utility. The higher the level at which minimum manning requirements are established the more likely a less than optimal allocation of accessions will occur and the greater the impact on total system net utility.

6. Initial declines in total system net utility from establishing low aptitude cutoffs scores can be considered a short-run phenomenon. Since the accession allocation module is maximizing expected total system net utility over 30 years of service, the equilibrium position for the system will be established at a higher total system net utility than if across-the-board minimum aptitude requirements are maintained.

Recommendations

SUMS is presently a prototype with several obvious avenues for future research:

1. Expansion of SUMS to a fully operating, force level software package,

2. Modification of SUMS to account for a two-tier upgrade system,

3. Extension of SUMS to allow analysis of more personnel policy decisions and management programs such as cross-training, severance pay, upgrade programs, etc.,

4. Extension of SUMS to account for other costs and values associated with enlisted personnel flows through the manpower system such as losses in productivity due to temporary duty assignments, moving costs associated with permanent change of stations, commissary costs and value, etc.,

5. Revision of SUMS' present utility theory to include additional analysis capability such as training program assessment, reenlistment bonus program assessment, cross-training assessment, etc.,

6. Consideration of methodologies for implementing economic and demographic effects on reenlistment/retention within the SUMS present continuation rate structure, and

7. Expansion of SUMS' capability to account for effects of premature attrition in the first year of service and the affects of premature attrition on costs.

8. Capability to fix output and solve for least cost.

9. Extension of SUMS to allow a front end analysis of recruiting resources and the size or quality of the accession pool.

10. Extension of SUMS to allow use of alternative productivity measure methodologies.

REFERENCES

FY88 Cost Factors, (1988). Director of Cost: DCS, Comptroller, HQ ATC, Randolph AFB, TX.

Boudreau, J.W. (1988). *Human resource management, evolving roles and responsibilities.* Washington, D.C.: Bureau of National Affairs, Inc.

Boudreau, J.W., & Berger, C.J. (1985). Decision-theoretic utility analysis applied to employee separations and acquisitions. *Journal of Applied Psychology,* 70.

Brogden, H.E. (1949). When testing pays off. *Personnel Psychology,* 2.

Carpenter, M.A., Monaco, S.J., & O'Mara, S.J. (1989). *Time to proficiency.* Paper prepared for the Training Systems Division, Brooks AFB, TX: Air Force Human Resources Laboratory.

Cascio, W.F. (1982). *Costing Human Resources: The Financial Impact of Behavior in Organizations.* Boston, MA: Kent.

Cronbach, L.J., & Gleser, G.C. (1965). *Psychological tests and personnel decisions.* Urbana: University of Illinois Press.

Faneuff, R.S., Valentine, L.D., Stone, B.M., Curry, G.L., & Hageman, D.C. (1990). *Extending the time to proficiency model for simultaneous application to multiple jobs.* (AFHRL-TP-90-42, AD A245 854). Brooks AFB, TX: Training Systems Division, Air Force Human Resources Laboratory.

Flemming, K., Cowardin, L.J., Reynolds, K., & Nielson, D. (1986). *A methodology for estimating the full cost of replacing trained Air Force personnel* (Working paper). Colorado Springs, CO: Department of Economics, Air Force Academy.

Hedge, J.W. (1984). *The methodology of walk-through performance testing.* Paper presented at the annual meeting of the American Psychological Association, Toronto.

Hull, C.L. (1928). *Aptitude testing.* New York: World Book.

Hunter, J.E., & Schmidt, F.L. (1982). Fitting people to jobs: the impact of personnel selection on national productivity. In *Human Performance and Productivity.* Hillsdale, NJ: Erlbaum.

Kelley, T.L. (1923). *Statistical method.* New York: Macmillan.

Landy, F.J., Farr, J.L., & Jacobs, R.R. (1982). Utility concepts in performance measurement. *Organizational Behavior and Human Performance*, 30.

Longmire, K.M., & Short, L.O., (1989). *Occupational research data bank: A key to MPTS analysis support.* AFHRL-TP-88-71, AD-A210-804. Brooks AFB, TX: Manpower and Personnel Division.

Saving, T.R., Stone, B.M., Looper, L.T., & Taylor, J., (1985). *Retention of Air Force enlisted personnel: An empirical examination.* (AFHRL-TP-85-6, AD A158 091). Brooks AFB, TX: Manpower and Personnel Division.

Schmidt, F.L., Hunter, J.E., McKenzie, R.C., & Muldrow, T.W. (1979). Impact of valid selection procedures on work-force productivity. *Journal of Applied Psychology*, 64.

Stone, B.M., Looper, L.T., & McGarrity, J.P., (1989b). *Validation and reestimation of an Air Force reenlistment analysis model*. Brooks Air Force Base, TX: Manpower and Personnel Division, Air Force Human Resources Laboratory.

Stone, B.M., Rettenmaier, A.J., Saving, T.R., & Looper, L.T. (1989a). *Cost-based value models of Air Force experience*. (AFHRL-TP-89-20, A212 771). Manpower and Personnel Division, Air Force Human Resources Laboratory, Brooks AFB, TX.

Stone, B.M., Saving, T.R., Turner, K.L., Looper, L.T., & Engquist, S.K. (1991). *A simultaneous estimation model of Air Force accession and retention*. (AL-TR-1991-0063, AD A240 064). Manpower and Personnel Research Division, Human Resources Directorate, Armstrong Laboratory, Brooks AFB, TX.

U.S. Department of Commerce, Bureau of the Census, (1986). *Current Population Survey*. Microdata File.

APPENDIX
INITIALIZING AND IMPLEMENTING SUMS

SUMS is comprised three major components: (1) an accession allocation model, (2) personnel flow model, and (3) utility assessment model. Each component provides necessary information to the other components which comprises the basis for the simulation. This appendix presents a detailed discussion of the mechanics of initializing and running SUMS. In addition, examples of the output of a SUMS simulation are explained.

Initializing SUMS

SUMS has the capability to run numerous alternative scenarios involving single or multiple career fields and one or more projection periods (up to 10 years). The SUMS prototype can run a maximum of four AFSs and project a maximum of 10 years. Numerous files are involved in the initialization of SUMS. The first file to be initialized is the "run.run" file. The "run.run" file sets:

(1) the file to which the output will be sent when the simulation has been completed. For example, sums.out as indicated in Table A-1,

TABLE A-1. RUN.RUN FILE EXAMPLE

```
sums.out

2 90

1

pool

1

scenario

TOTALPOP
TOTALUTIL
TOTALVALUE
TOTALCOST
```

(2) the number of time periods to be simulated up to a maximum of 10. Table A-1 has indicated 2 time periods to be simulated,

(3) the beginning time period. For example, 90 if the first time period is 1990 (Table A-1),

(4) the name of the file containing the aptitude mix of the accession pool (pool in Table A-1),

(5) the name of the file containing additional parameters to perform the desired scenario (scenario in Table A-1). A detailed discussion of this file is next, and

(6) the desired performance measures by projection year, at least one is required. The choices are: (1) AVGPROD - average productivity, (2) TOTALPOP - total population, (3) TOTALUTIL - total utility, (4) TOTALVALUE - total value, (5) TOTALCOST - total cost, and (6) SKILLPROFILE - skill profile. Table A-1 identifies four of these performance measures: TOTALPOP, TOTALUTIL, TOTALVALUE, and TOTALCOST.

The next file to be initialized is the "scenario.scn" file which was specified in the "run.run file." The "scenario.scn" file sets:

(1) the number of career fields to be included in the simulation (maximum of 4, Table A-2),

TABLE A-2. SCENARIO.SCN FILE EXAMPLE

4
a1220
a2720
a4262
a4921
1300 1300

(2) the identification number of each of the career fields to be included in the simulation. For example, 2720 in Table A-2 for AFS 272X0, Air Traffic Controllers,

(3) the size of the accession pool, i.e., 1,300 in Table A-2, for each of the projected time periods, and

Next, a file is initialized for each of the career fields to be included in the analysis, "axxxx.afs" files, where the xxxx is the 4-digit code identifying the career field, e.g., 2720 for air traffic controllers. The "axxxx.afs" file sets:

(1) the ASVAB composite score used to allocate accessions to the career field, i.e., M for mechanical, A for administrative, G for general, or E for electronic. Career fields are presently restricted to one of the four composite scores. For example, G in Table A-3 represents the general composite score which is used for AFS 122X0,

(2) the number of aptitude categories. Presently, SUMS provides for 10 categories of aptitude (Table A-3): 90 to 99, 80 to 89, 70 to 79, 60 to 69, ..., 10 to 19, 0 to 9,

(3) the number of skill categories for the career field. Presently, SUMS provides for 4 skill categories (Table A-3): 3 for semi-skilled, 5 for skilled, 7 for advanced, and 9 for superintendent/manager,

(4) the class files for each of the aptitude/skill/AFS cohorts. For example, file "c1220570.cls" (Table A-3) includes data for AFS 122x0, skill level 5, and aptitude 70,

(5) the OJT costs by YOS for the career field (Table A-3),

(6) the technical training costs by YOS for the career field (Table A-3),

(7) the BMT for the career field. Presently, BMT does not differ by career field. For example, $6,415.00 in Table A-3,

(8) the minimum aptitude score allowed for accessions to enter the career field (40 in Table A-3),

(9) the manning levels for each designated skill level for the career field. For example, 120, 720, 385, and 50 for Year 1 of AFS 122X0 in Table A-3,

(10) the portion of an overage, if one occurs, which will be forced out of the career field by skill level (1.0 in Table A-3),

(11) the portion of personnel who need to be upgraded to the next skill level by skill level for the career field (1.0 in Table A-3). This fraction is applied equally against each YOS group and causes the specified fraction to be skipped over in the upgrade phase,

(12) the minimum number of years of service required to be qualified for upgrade from one skill level to the next for each designated skill level. For example, 1, 6, and 16 for AFS 122X0 in Table A-3,

TABLE A-3. THE "AXXXX.AFS" FILE EXAMPLE

```
G
9
90 80 70 60 50 40 30 20 10

4
3 5 7 9

90 3 c1220390   90 5 c1220590   90 7 c1220790   90 9 c1220990
80 3 c1220380   80 5 c1220580   80 7 c1220780   80 9 c1220980
70 3 c1220370   70 5 c1220570   70 7 c1220770   70 9 c1220970
60 3 c1220360   60 5 c1220560   60 7 c1220760   60 9 c1220960
50 3 c1220350   50 5 c1220550   50 7 c1220750   50 9 c1220950
40 3 c1220340   40 5 c1220340   40 7 c1220740   40 9 c1220940
30 3 c1220330   30 5 c1220530   30 7 c1220730   30 9 c1220930
20 3 c1220320   20 5 c1220520   20 7 c1220720   20 9 c1220920
10 3 c1220310   10 5 c1220510   10 7 c1220710   10 9 c1220910

1616.41 6066.58 7949.22 6204.21 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00

1916.61 4181.42 4228.85 733.85 1225.02 605.67 89.65 373.39 278.00 389.21
518.94 370.67 0.00
0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
0.00

6415.00

40 120.0 1.0 1.0 1 720.0 1.0 1.0 6 385.0 1.0 1.0 16 50.0 1.0 1.0 0
40  90.0 1.0 1.0 1 540.0 1.0 1.0 6 289.0 1.0 1.0 16 38.0 1.0 1.0 0

1.05 1.1025
1.025 1.051
1.041 1.084
1.025 1.051
1.025 1.051
1.025 1.051
1.0 1.0
```

(13) the minimum manning requirement for the AFS (0 in Table A-3). Accessions are allocated to insure that minimum manning requirements for each AFS are met based on the AFS-specific demand for accessions and the availability of accessions to meet the minimum manning levels across AFSs, and

(14) the proportional change expected to occur in each projected time period for each of seven factors. Changes are based on the starting value for the factor. For example, a desired change of 5% per year for a 2-year projection would be presented as 1.05 for Year 1 and 1.1025 for Year 2 (Table A-3). The seven factors (in order presented in Table A-3) are service state values, separation costs, regular military compensation, OJT costs, technical training costs, BMT costs, and productivity.

Finally, a file for each of the aptitude/skill level/AFS cohorts is initialized, "cxxxxyzz.cls" files, where the xxxx is the 4-digit code identifying the career field, e.g., 2720 for air traffic controllers, y is a code identifying the skill level, e.g., 3 for semi-skilled, and zz is a 2-digit code identifying the aptitude category, e.g., 20 for aptitude cohort 20 to 29. The "cxxxxyzz.cls" file sets six groups of values as presented in Table A-4:

(1) the productivity values by YOS,

(2) the continuation rates by YOS,

(3) the beginning inventory by YOS,

(4) the service state values by YOS,

(5) the separation costs by YOS, and

(6) the RMC by YOS.

The "run.run," "scenario.scn," "axxxx.afs," and "cxxxxyzz.cls" files provide the parameters necessary to initialize SUMS.

TABLE A-4. THE "CXXXXYZZ.CLS" FILE EXAMPLE

```
0.973 0.983 0.994 1.004 1.013 1.023 1.032 1.040 1.049 1.057
1.064 1.072 1.079 1.085 1.092 1.098 1.103 1.109 1.114 1.118
1.123 1.127 1.131 1.134 1.137 1.140 1.142 1.144 1.146 1.147
1.148

-1
 .906  .911  .889  .600  .895  .900  .958  .867  .842  .769
 1.000 1.000 1.000 1.000  .909 1.000 1.000 1.000 1.000  .833
 .857  .600  .500  .000  .000  .000  .000  .000 1.000  .000
 .000

0.000 10.000 29.000 20.000 18.000 14.000 9.000 3.000 2.000 0.000
0.000 1.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000

 17887.896 20384.938 22811.885 25168.729 27455.477
 29893.064 32310.094 34706.539 37082.402 38746.563
 40341.719 41867.871 43325.027 44532.746 45670.363
 46737.887 47735.312 48662.652 49519.895 50307.043
 51024.094 51671.059 52247.922 52754.707 53191.395
 53557.988 53854.477 54080.883 54237.195 54323.406
 54339.520

0.000 0.000 0.000 0.000 781.200 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000

15582.38 15946.380 16777.600 18079.699 19172.461
19214.59 19887.539 20159.369 26923.770 26220.369
26036.47 25840.320 26717.211 26641.080 27133.760
27580.46 26954.410 26954.410 26954.410 26954.410
26954.41 26954.410 26954.410 26954.410 26954.410
26954.41 26954.410 26954.410 26954.410 26954.410
26954.41
```

SUMS Simulation

SUMS evaluates the utility of varying force structures, personnel management programs, accession policies, compensation issues, upgrade policies, and reenlistment/retirement policies through several performance/value/cost related measures. These measures are the product of personnel flow simulations based on a time dependent model of the enlisted personnel system. The simulation model is concerned with time dependent updating of the manpower profiles; computing separations, upgrades and accessions; and evaluating the requested measures of effectiveness for the various scenarios defined. This is accomplished by a yearly time step updating procedure which performs three basic functions in the following order:

(1) updating AFS profiles by aging the manpower profile and computing natural separations,

(2) computing upgrades and/or forced separations, if necessary, and

(3) computing accessions to be drawn from the recruit pool.

SUMS begins with user initialization of its parameters and then performs the simulation of the desired scenario. The continuation rates by YOS for each AFS skill and aptitude class are used to obtain the natural attrition from the force for the specific job classification. Then the manning goals for the scenario by AFS skill category are applied. If the post-separation force levels are above the skill level goals, then forced separations are imposed. Flexibility in the meeting of these goals is imbedded into the system by allowing the user to specify a number which determines how strictly the goals are to be met. The base number of 1.0 requires that forced separations be imposed so as to exactly meet the specific AFS/skill level goal. Specifying a fraction (a number less than 1.0) allows forced separations to be less severe, while a number larger than 1.0 allows for creating manning vacancies into which upgrades can occur.

Starting at the highest skill level, upgrades from the immediate preceding skill level are computed to fill the manning level deficiencies which may or may not occur. The number of upgrades from any skill level are constrained by an eligibility requirement based on YOS and specified by the user. Upgrades are also constrained by a user-specified proportion representing the number of potential upgrade personnel being passed over for upgrade. This procedure is repeated for each skill level in turn, proceeding from the highest to the lowest skill category. The deficiency created at the entry level skill category plus any deficiencies after upgrade of any higher skill levels is then used as the accession goal for that AFS in the accession allocation process.

The accession allocation routine uses the manpower demands by AFS along with a supply pool to optimally allocate accessions by aptitude category to the various AFS's. The measure used to make this allocation is the expected net utility from being allocated to a particular AFS over a 30 YOS career horizon of an individual of

specified aptitude. The pool population is segmented into 10^4 categories based on the four aptitude scores (10,000 categories). Each group is further segmented into categories of individuals who are allocated to each of the AFS's. The resulting optimization problem is solved using a transportation algorithm (a linear programming approach) with as many demands for accessions as there are AFS's and 10,000 times the number of AFS's as the number of supplies (Faneuff et al., 1990).

Upon completion of the accession allocation, SUMS calculates the total net system utility accruing from the force for the time period. The simulation is repeated for each projected time period. The system facilitates comparison of different multi-period force scenarios by permitting several scenarios to be submitted at the same time. A variety of performance measures are made available addressing inventory management, costs, value, and system utility.

SUMS derives its uniqueness from the scope and flexibility of its analysis capabilities. For example, if there are four skill level categories (3, 5, 7 and 9) for each AFS and the force profile can be categorized into ten aptitude categories (90, 80, 70, ... , 10, 0), then each AFS in the analysis would consist of 4 times 10 "cxxxxyzz.cls" files. Thus, each analysis of a scenario consisting of four AFS's would require the maintaining and updating of 160 "cxxxxyzz.cls" files. Since SUMS allows the user to expand the number of skill and aptitude categories, the number of class files and the complexity of the analysis can be increased significantly.

SUMS Output

Output from SUMS is comprised of: (1) the net utilities used for accession allocations and the resulting accession allocation into each AFS by aptitude, and (2) the total system measures of performance by year such as total manpower levels, total costs, net utility, actual manning levels, accessions, separations, upgrades, etc.

Utilities For Accession Allocation

The value, cost and net utility of allocating an individual of a given aptitude to an AFS can vary over time. The simulation periods are 1 year, so these utility factors are printed at the beginning of each yearly iteration. Table A-5 presents an example of value, cost, and net utility for a single projection year. The net utility column is an expected net utility measure associated with accessing a recruit with a given aptitude into a particular career field and progressing him/her through 30 years of service. The expected part of the net utility estimate results from the probability of separation at each YOS.

Expected net utility by AFS and aptitude is used in the optimization of the accession allocation (Faneuff et al., 1990). The optimization scheme searches for an allocation of the available accession pool which maximizes the total net utility accruing to the Air Force across all accessions and career fields included in the scenario.

Measures of Performance from the Simulation Output

Table A-6 presents an example of the output provided from the first year of a 5-year simulation. The same information is provided for each year of a simulation for each career field included in the scenario. Manning goals represent the targeted goals set by the user for each skill level. Initial inventory is the number of enlisted personnel present in each skill level at the beginning of the simulation. Separations are the number of personnel who separate from active duty by skill level during the projected time period. Separations are responsible for opening slots for upgrade during the projected time period since SUMS upgrades to fill.

Upgrades are the number of personnel upgraded from one skill level to the next during the projected time period. Accessions are the number of new recruits required to meet overall manning goals for the career field. At present, accessions only occur in skill level 3, thus, cross-training and prior service accessions are not presently included in SUMS capability. Force outs represent the number of personnel who were forced out of active duty due to an overage in the career field. Shortage (Overage) is the number of personnel short or over the career field goal after the projected time period. Ending inventory is the number of personnel in each skill level at the end of the projection period.

Four additional sets of information are provided for each projected year across AFSs concerning the total system population, the total personnel cost, the total value, and the total net utility.

UTILITY

Yr	Total Population	Total Cost	Total Value	Net Utility
90	7,540			
91	9,530	$215,625,392	$254,812,480	$39,187,090
92	8,687	211,809,104	262,623,568	50,814,460

Thus, the user is provided with a means of assessing total system utility resulting from varying accession/retention policies and alternative force structures.

TABLE A-5. NET RETURNS FOR APTITUDE GROUPS BY AFS: YEAR 1

AFS	Aptitude	Value	Cost	Net Utility
	90	$140,657	$134,891	$5,766
	80	140,232	134,891	5,341
	70	139,819	134,891	4,928
	60	139,364	134,891	4,474
122X0	50	138,956	134,891	4,065
	40	138,539	134,891	3,648
	30	138,116	134,891	3,225
	20	137,703	134,891	2,812
	10	137,284	134,891	2,393
	90	166,052	135,602	30,451
	80	165,908	135,602	30,307
	70	165,765	135,602	30,164
	60	165,685	135,602	30,084
272X0	50	165,555	135,602	29,953
	40	165,405	135,602	29,803
	30	165,274	135,602	29,672
	20	165,148	135,602	29,546
	10	165,066	135,602	29,465
	90	147,142	132,154	14,989
	80	146,420	132,154	14,267
	70	145,692	132,154	13,538
	60	144,979	132,154	12,826
426X2	50	144,232	132,154	12,078
	40	143,504	132,154	11,351
	30	142,773	132,154	10,619
	20	142,040	132,154	9,887
	10	141,326	132,154	9,173
	90	155,191	148,087	7,104
	80	154,747	148,087	6,660
	70	154,302	148,087	6,215
	60	153,877	148,087	5,790
492X1	50	153,435	148,087	5,348
	40	153,009	148,087	4,922
	30	152,550	148,087	4,464
	20	152,105	148,087	4,019
	10	151,682	148,087	3,595

TABLE A-6. SIMULATION RESULTS FOR A 5-YEAR PROJECTION: YEAR 1

	Skill Levels 3	5	7	9	Total
122X0					
Manning Goals	120	720	385	50	1,275
Initial Inventory	121	720	386	46	1,273
Separations	10	87	26	8	131
Upgrades	0	111	37	12	159
Accessions	133	0	0	0	133
Forced Outs	0	0	0	0	0
Shortage (Overage)	13	-13	0	0	0
Ending Inventory	133	707	385	50	1,275
272X0					
Manning Goals	250	1,220	1,105	175	2,750
Initial Inventory	249	1,218	1,105	173	2,745
Separations	17	141	75	31	264
Upgrades	0	232	108	33	373
Accessions	269	0	0	0	269
Forced Outs	0	0	0	0	0
Shortage (Overage)	19	-19	0	0	0
Ending Inventory	269	1,201	1,105	175	2,750
426X2					
Manning Goals	490	1,840	950	125	3,405
Initial Inventory	488	1,842	947	127	3,404
Separations	38	225	58	27	348
Upgrades	0	310	86	25	421
Accessions	349	0	0	0	349
Forced Outs	0	0	0	0	0
Shortage (Overage)	0	0	0	0	0
Ending Inventory	490	1,840	950	125	3,405
492X1					
Manning Goals	145	580	340	35	1,100
Initial Inventory	145	579	340	34	1,098
Separations	11	51	17	5	83
Upgrades	0	74	23	6	102
Accessions	85	0	0	0	85
Forced Outs	0	0	0	0	0
Shortage (Overage)	0	0	0	0	0
Ending Inventory	145	580	340	35	1,100

*U.S. GOVERNMENT PRINTING OFFICE 1992-0-661-049/60025